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Transnasal 3D endoscopic skull base surgery: questionnaire-based analysis of the learning curve in 52 procedures

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Abstract In the past decade, surgical treatment of skull base pathologies has greatly advanced through the advent of the endoscope and later of the high definition endoscope. Recently a new type of three dimensional (3D) scope has been introduced to permit the surgeon a real stereoscopic vision of the operating field and to overcome the limitations of the 2D endoscopic set up. As with all new technologies a formalized adaptation period is essential for the surgeon to secure steady outcomes and low complications. To determine the subjective difficulties that one may encounter during this sensitive period we therefore devised and analyzed a questionnaire that evaluated the first ten procedures with the 3D device of junior and senior ENT and neurosurgeons. 52 consecutive patients were treated with purely 3D transnasal endoscopy for skull base pathologies. Sensation of strain or dizziness, difficulties in anatomical orientation and difficulties in performing the surgical gesture were assessed for each surgeon. The learning curve and difficulties of junior and senior surgeons are discussed and strategies to overcome the initial problems are devised. Our results confirm that after only few procedures, the advantages of the 3D endoscopic system including better visualization and depth perception are able to outweigh the inconveniences that go hand in hand with the learning of a new skill set.

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Introduction

Transnasal endoscopic approaches to the skull base are now considered a sound alternative to open craniofacial approaches when managing skull base neoplasms [1]. These approaches were employed initially by otolaryngologysts, but in the past decade they underwent a wide acceptance among neurosurgeons alike, partly due to the development of instrumentation and visualization technology that facilitate the access and exposure to the skull base [2]. Nonetheless, the lack of stereoscopic vision while using the two dimensional (2D) endoscope is a restriction, mostly felt in the posterior nose and during the neurosurgical part of the operation [3]. Although visual cues like the interaction of instruments or the back and forth movement of the endoscope may help constructing a virtual three dimensional (3D) image inside the surgeon's brain, these mechanisms are partly lost during neurosurgical approaches when using a holder. The "two nostrils four hands technique" seems to improve vision for the surgeon because of its more dynamic handling of the scope, nonetheless depth perception remains only fairly accurate. To overcome these limits, a novel 3D visualization system has been developed (Visionsense, Ltd., Petach Tikva, Israel) and more than one publication has demonstrated its effectiveness and safety during sinonasal and skull base surgery [4–6].

Similar to the shifting from the use of microscopes to endoscopes for the transnasal approaches, the handling of the 3D system needs an adjustment period while surgeons acquire new surgical skills and gain experience.

Advantages of the 3D endoscopic system include visualization and depth perception, but it has not been analyzed at what point they are able to outweigh the inconveniences that go hand in hand with the learning of a new skill set.

Aim of this study was to report our first experience with the 3D system applied to skull base surgery and to analyze the subjective difficulties while using the 3D system for the first times. As a consequence, we report our strategies to overcome them.

Patients and Methods

All patients who underwent 3D endoscopic skull base surgery between May 2011 and February 2012 at the Humanitas Clinical Institute of Rozzano, Milan, Italy, were enrolled in the study. A total of 52 cases were collected.

All patients were preoperatively studied with both CT and MRI scans. All surgeries were performed under general anesthesia with the patient in the supine position. The surgical team was always composed of at least an otolaryngologist and a neurosurgeon. Surgical approaches were performed by two senior ENT surgeons (more than 300 endoscopic approaches to the skull base with the 2DHD system), three junior ENT surgeons (<6 approaches), 1 senior neurosurgeon (>400 endoscopic procedures on the skull base with the 2DHD system), and two junior neurosurgeon (less than 10 endoscopic procedures).

The surgeons gained initial experience with approaches to exclusively sellar pituitary tumors, progressing (for the senior surgeons) to more extended approaches to the skull base towards the end of the case series.

Lumbar drains were not used on a routine basis. Perioperative antibiotic prophylaxis was always administered. Neuronavigation was used in 14 cases. In 11 cases, the operation was carried out through an extended endonasal approach (EEA). In these patients, reconstruction was performed with a multilayer technique using fascia lata underlay (one layer intradural and one extradural) and naso-septal flap overlay. In standard transphenoidal approaches, sellar reconstruction was performed using abdominal fat and septal bone graft in case of low-flow intraoperative CSF leak. In patients with high-flow CSF leak, reconstruction was performed with fascia on the diaphragm, abdominal fat in the sellar cavity, and a vascular pedicled septal flap. Reconstruction was not necessary in sellar defects without intraoperative CSF leak.

Patients were followed prospectively for incidence of postoperative complications including hemorrhage, CSF leak, visual impairment, or ophthalmoplegia. Postoperative follow-up included endocrinologic study, endoscopic evaluation, and MRI.

At the end of each of their first ten operations, the otolaryngologist and the neurosurgeon each filled out a questionnaire regarding that surgery. The response options to the questions on the form were close-ended (scale from 0 to 10, 0: none) for questions 1–3 and open-ended for question numbers 4 and 5:

1. Sensation of strain or dizziness (0–10),
2. Difficulties in anatomical orientation (0–10),
3. Difficulties in performing the surgical gesture (0–10),
4. Number of switches from 3D to 2D,
5. Personal considerations.

Questionnaires were matched separately for the senior ENT surgeons, junior ENT surgeons as well as senior and junior neurosurgeons and then compared. Evaluation of the questionnaires' scores was performed using graphic rendering of the mean results for each surgical subcategory.

Technology

The 3D stereoendoscopes (0° wide angle and 30°) by Visionsense (Visionsense, Ltd., Petach Tikva, Israel) were used in all cases. The system is based on a lenticular array and the three-dimensionality is conveyed by two single cameras mounted on the tip of the endoscope [3]. The image is displayed on a 42-inch dual-flatscreen mounted on the device's tower. Polarizing glasses are worn for 3D visualization. The system records still-frames and movies and allows a switch from 3D to 2D via a key on the handle of the endoscope.

Results

Of the 52 operated patients, 23 were males and 29 were females. Mean age at surgery was 49.3 ± 17.1 years. 39 patients underwent a classical endoscopic transphenoidal approach, while an extended approach was performed on 11 patients. The series includes 43 patients treated for adenomas: 9 micro adenomas, 32 macro, and 2 giant adenomas, and 7 patients with neoplastic lesions out of which two metastasis, two craniopharyngiomas, two meningiomas and one non-Hodgkin lymphoma. At the intraoperative evaluation, complete resection of the lesion was obtained in 38 cases. In the other patients a various degree of residual disease was present at the end of the operation.

No major intraoperative complications were recorded. Six patients (16.6 %) presented a postoperative CSF leak successfully treated with revision surgery. One patient presented a left sided amaurosis due to an intrasellar hematoma that was resolved with surgical evacuation.

Questionnaire Results

The results of the questionnaires concerning sensation of strain or dizziness, difficulties in anatomical orientation, and difficulties in performing the surgical gesture are reported in the following graphs (Fig. 1–4).

Sensation of strain and dizziness

Strain and dizziness were observed more frequently among ENT surgeons (both senior and junior) but they were overcome by the fourth procedure. Instead, junior neurosurgeons experienced prolonged problems during all ten procedures, although progressively less severe (Fig. 1).

Difficulties in anatomical orientation

Difficulties in anatomical orientation were greatest during the first 2–3 procedures, and progressively improved for all surgeons. Senior surgeons experienced a second peak of difficulties between the fifth and eighth procedure for ENT surgeons and between the seventh and eighth procedure for the neurosurgeon. Junior ENT surgeons showed initially more problems than junior neurosurgeons (Fig. 2).

Difficulties in performing the surgical gesture

Junior ENT surgeons showed persistent but decreasing troubles, so did the junior neurosurgeons only slightly less. Senior surgeons did not show any problem after the second (neurosurgeon) and the fourth (ENT surgeon) procedures (Fig. 3).

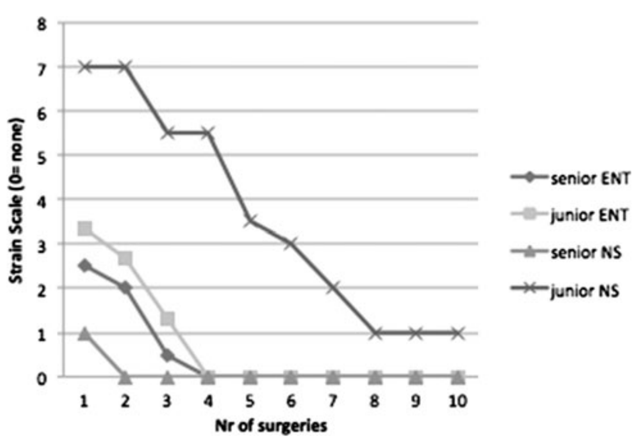

Fig. 1 Level of strain and dizziness (0–10; 0: none) felt by the surgeons (senior ENT and—neurosurgeons, junior ENT and—neurosurgeons) during each of their first ten surgeries with the 3D system: the junior neurosurgeon experienced prolonged problems while the senior neurosurgeon had only few difficulties with strain and dizziness. ENT surgeons (both senior and junior) showed some strain, which was overcome by the fourth procedure

The number of switches from 3D to 2D

The number of switches from 3D to 2D as an indicator of general discomfort or difficulty was relevant only for the senior surgeons that used this possibility up to five times during the first two surgeries. No need for switches was achieved after two surgeries. Junior surgeons had a very limited need to switch from 3D to 2D, and only one switch was reported for one junior ENT surgeon (Fig. 4).

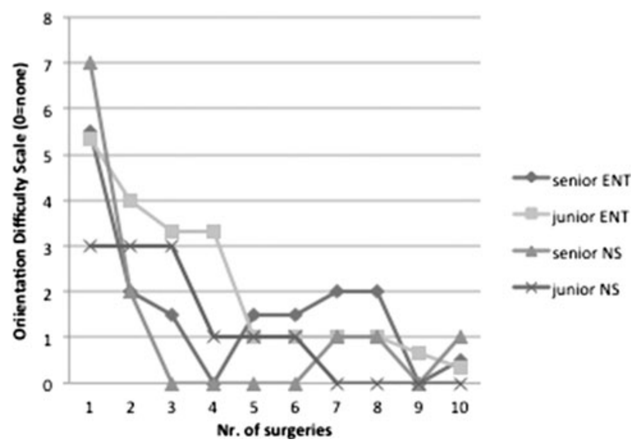

Fig. 2 Perceived difficulty in anatomical orientation (0–10; 0: none) felt by the surgeons during each of their first 10 surgeries with the 3D system: difficulties in anatomical orientation were greatest during the first 2–3 procedures, and progressively improved for all surgeons. Senior surgeons experienced a second peak of difficulties between the 5th and 8th procedure for ENT surgeons and between the 7th and 8th procedure for the neurosurgeon

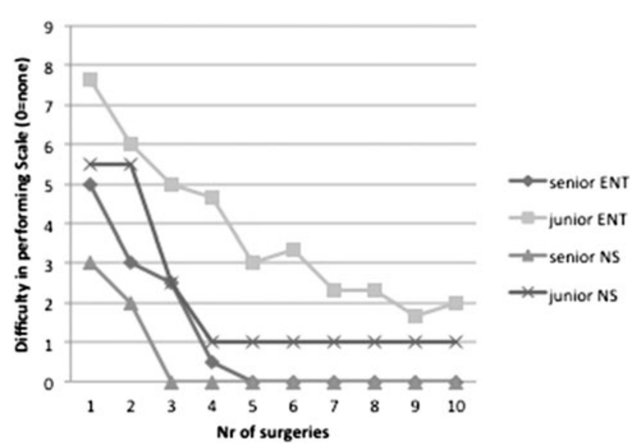

Fig. 3 Difficulty experienced by the surgeons in performing the surgical gesture during each of their first ten surgeries with the 3D system: junior ENT surgeons showed persistent but decreasing troubles, so did the junior neurosurgeons. Senior surgeons did not show any problem after the second (neurosurgeon) and the fourth (ENT surgeon) procedures

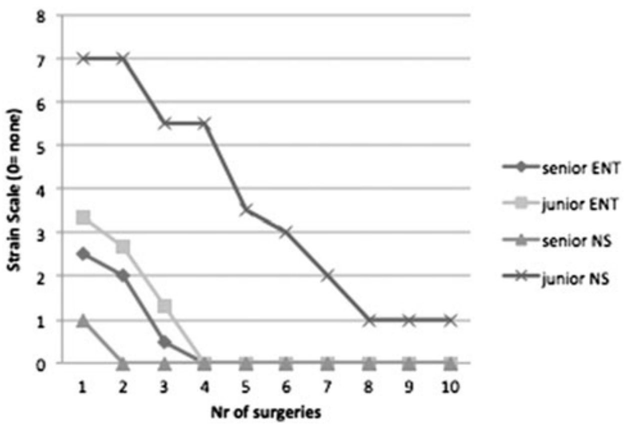

Fig. 4 Total number of switches from 3D to 2D performed by the surgeons during each of their first ten surgeries with the 3D system: senior surgeons switched up to five times during the first two surgeries. No need for switches was achieved after two surgeries. Junior surgeons had very limited need to switch from 3D to 2D

Personal considerations

The surgeons reported a good acceptance of the device. Plasticity and recognition of landmarks were very accurate, but image colors were reported to be less realistic than with the 2D-HD equipment. Moreover, the surgeons were unable to use the "two nostrils four hands" technique with ease or at all due to the autofocus system of the Visionsense, which made it harder for the surgeon to work in the periphery of the image as accustomed.

Discussion

The acquisition of new skills using new technologies is an ongoing challenge for surgeons throughout their career. Typically, achievement of proficiency may vary depending on the prior experience and skills of the surgeon. Therefore, investigation of occurring difficulties, for specific technologies, for every training level is pivotal for understanding the necessary learning curve [7].

The proposed advantages of the novel 3D device in visualization and depth perception have already been confirmed by the first comparative publications on the matter [3, 5, 6, 8] and its utility has been proven in small case series [4, 9]. Our experience confirms these findings on a large series of patients. Although we have not statistically compared the present results with our previous experience with the 2D-HD, we feel that there has not been an increase in the operative time and/or the length of hospital stay using the 3D system. Furthermore we feel that due to the more precise intraoperative dissection, the rate of gross tumor removal has improved. We could not attribute any intraoperative or postoperative complication to the new tool.

There is a significant amount of literature assessing the learning curve for a new procedure. The learning curve can be defined as a time after which a procedure may be performed safely and with a plateau in efficiency. For endoscopic transnasal pituitary surgery, these numbers range from as few as 17 surgical procedures [10] to 30–50 procedures [7]. Our findings show that senior surgeons (both otolaryngologists and neurosurgeons) became proficient in using the 3D endoscope very quickly. They experienced initial slight strain and dizziness during the first 2/3 procedures, but showed no more feeling of discomfort after that. The same, but with higher initial scores, was seen for the junior otolaryngologists. In contrast to this, junior neurosurgeons reported decreasing but persistent strain during all first ten procedures. This may be explained by the fact that the novel neurosurgeon is not familiar with the use of transnasal endoscopy, making adaptation to the new 3D technology more difficult. However, junior surgeons seem to adapt more easily to the new visualization as proven by less 2D–3D switches in comparison to the senior surgeons.

Quick proficiency was reached for anatomical orientation for both senior otolaryngologists while working on pituitary tumors, but a second learning phase was observed while dealing with more extended approaches. The senior neurosurgeon had only slight difficulties adapting to the different 3D visualization of anatomical landmarks during the first two procedures and not during the approaches to parasellar lesions. The junior ENT group needed more time to become proficient than the junior neurosurgeons. This may be partly related to the complexity of nasal anatomy, which may have more variations than the sellar region. Difficulties in performing the surgical gesture was seen for junior ENT surgeons and, with lower scores, for junior neurosurgeons, as may be expected for a novel surgeon. Senior surgeons only reported imprecision during the first 2/3 surgeries. This may be correlated not only to a visualization problem, but also to a conflict of the less handy instrumentation (bigger diameter of the scope, autofocus, less life-like colors of the image). In this regard it may be of some interest that, although the senior surgeons have a second peak in difficulties of orientation while confronted with more complex cases, these difficulties do not translate into problems of surgical precision. This may be partly explained by the fact that the more complex cases need a more extended approach, consequently granting more space for movement of the scope and an easier focusing, therefore overcoming the 3D endoscope inconveniences.

With the introduction of any surgical technology an adjustment time is expected but we believe this period can be shortened in the case of the novel 3D device using strategies that have been developed by fellow surgeons. For example, distancing the monitor from the operator and narrowing the image on the screen can overcome initial mild dizziness. The two camera system is more susceptible to conveying a foggy image during the narrow nasal part of the surgery if one of the two cameras is dirty. A solution could be a high irrigation frequency or, if happening during a critical step of the procedure, the closing of the ipsilateral eye of the surgeon to the unclean camera. General proficiency progresses after understanding that the movement of the endoscope has to be slower due to the autofocus feature and the tip of the endoscope needs to be farther away from the surgical field in comparison with the 2D endoscope. This issue caused problems in performing a "two nostril four hands" technique. Nonetheless, we are convinced that through experience and technological improvements this will no longer be a concern in the near future. We believe that, after the initial adaptation period, the same limitations for using the endoscope apply for 3D as for 2D endoscopy. Nonetheless, the advantages of 3D images are more evident while working in wider spaces like the sphenoid sinus and the skull base. All participants tended to prefer the 3D endoscopic system as it allowed a more secure feeling and subjective precision in dissecting the structures once acquainted with the anatomy. Of course validation of our data with larger series is needed, as for more junior surgeons the learning curve might be longer than just ten surgeries. Nonetheless, we believe that this study is representative in the case of a switch from 2D to 3D devices in senior surgeons as we intended to analyze only the adaptation period.

Conclusion

Although the novel 3D endoscopy has its minor limitations, these can easily be overcome through a brief training period for junior and senior surgeons. We believe this technology to have more advantages in the posterior, wider spaces of the nose and skull base and therefore to be of great promise for improving microneurosurgical dissection transnasally. In addition, although nothing can replace the knowledge of anatomy, neuronavigation can help orient the surgeon and speed the learning curve. Cooperation and communication of the multidisciplinary team are pivotal for a safe and smooth transition from 2D to 3D.

Conflict of interest All authors declare that they have no conflict of interest (financial or otherwise).

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